SCXI™

SCXI-1521/B User Manual

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Conventions

The following conventions are used in this manual:

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, P0.<3..0>.
»	The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.
	This icon denotes a note, which alerts you to important information.
	This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this icon is marked on the product, refer to the *Read Me First: Safety and Radio-Frequency Interference* document, shipped with the product, for precautions to take.
	When symbol is marked on a product it denotes a warning advising you to take precautions to avoid electrical shock.
	When symbol is marked on a product it denotes a component that may be hot. Touching this component may result in bodily injury.
bold	Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.
italic	Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.
`monospace`	Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.
`monospace bold`	Bold text in this font denotes the messages and responses that the computer automatically prints to the screen. This font also emphasizes lines of code that are different from the other examples.
SCXI-1521/B	SCXI-1521/B refers to both the SCXI-1521 and the SCXI-1521B module, unless otherwise noted.

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1

About the SCXI-1521/B

This chapter introduces the SCXI-1521/B module, and explains how to install the software and hardware.

Note Descriptions in this chapter explicitly refer to the first channel (channel 0), but these descriptions also are applicable to the remaining 23 channels.

The SCXI-1521 and SCXI-1521B modules are 24-channel modules for interfacing to quarter-bridge strain gauges and are configured using Measurement & Automation Explorer (MAX) or through NI-DAQmx property nodes. The SCXI-1521 has 350 Ω completion resistors while the SCXI-1521B has 120 Ω completion resistors.

The SCXI-1521/B includes the following functionality:

- DC voltage excitation between 0 and 5 V in 1023 steps
- Programmable offset nulling circuitry
- 10 Hz lowpass filter
- Analog input gain of 42 V/V
- Software controllable shunt calibration

What You Need to Get Started

To set up and use the SCXI-1521/B, you need the following:

- ❑ Hardware
  - SCXI-1521/B module
  - SCXI-1317 terminal block
  - SCXI or PXI/SCXI combo chassis
  - Computer if using an SCXI chassis
  - Cabling, cable adapter, and sensors as required for your application

- ❑ Software
  - NI-DAQmx 7.3 or later
  - One of the following software packages:
    - LabVIEW
    - LabWindows™/CVI™
- ❑ Documentation
  - *Read Me First: Safety and Radio-Frequency Interference*
  - *DAQ Getting Started Guide*
  - *SCXI Quick Start Guide*
  - *SCXI-1521/B User Manual*
  - *SCXI-1317 Terminal Block Installation Guide*
  - Documentation for your software

The optional accessories listed in Table 1-1 are available for the SCXI-1521/B.

Table 1-1. Accessories Available for the SCXI-1521/B

Accessory	Description
SCXI-1317	Screw terminal block—Mounts on the front of the SCXI-1521/B module and provides easy access to the terminal for field wiring connections.
SCXI-1310	Connector and shell assembly—Provides 96 eyelet-type terminals for easy hook-and-solder signal connection and custom mass termination connectivity.
TBX-96	DIN-rail mounted terminal block with 96 generic screw terminals. One of the following cables is required to connect the TBX-96 to an SCXI module: • SH96-96 shielded cable, 1 m • R96-96 unshielded ribbon cable, 1 m

National Instruments Documentation

The *SCXI-1521/B User Manual* is one piece of the documentation set for data acquisition (DAQ) systems. You could have any of several types of manuals depending on the hardware and software in the system. Use the manuals you have as follows:

- SCXI or PXI/SCXI chassis manual—Read this manual for maintenance information about the chassis and for installation instructions.
- The *DAQ Getting Started Guide*—This document has information about installing NI-DAQ and the E/M Series DAQ device. Install these before you install the SCXI module.
- The *SCXI Quick Start Guide*—This document contains a quick overview for setting up an SCXI chassis, installing SCXI modules and terminal blocks, and attaching sensors. It also describes setting up the SCXI system in MAX.
- The SCXI hardware user manuals—Read these manuals next for detailed information about signal connections and module configuration. They also explain, in greater detail, how the module works and contain application hints.
- Accessory installation guides or manuals—If you are using accessory products, read the terminal block and cable assembly installation guides. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making the connections.
- The E/M Series DAQ device documentation—This documentation has detailed information about the E/M Series DAQ device that plugs into or is connected to the computer. Use this documentation for hardware installation and configuration instructions, specification information about the E/M Series DAQ device, and application hints.
- Software documentation—You may have both application software and NI-DAQ software documentation. National Instruments (NI) application software includes LabVIEW, LabWindows/CVI, and Measurement Studio. After you set up the hardware system, use either your application software documentation or the NI-DAQ documentation to help you write your application. If you have a large, complex system, it is worthwhile to look through the software documentation before you configure the hardware.

- The **Start»Programs»National Instruments»NI-DAQ» NI-DAQmx Help** files for software information.
- NI strain-gauge application notes or tutorials—NI has additional material about strain gauges and strain measurements available at `ni.com/support`.

You can download NI documents from `ni.com/manuals`.

Installing the Application Software, NI-DAQ, and the DAQ Device

Refer to the *DAQ Getting Started Guide*, packaged with the NI-DAQ software, to install your application software, NI-DAQ driver software, and the DAQ device to which you will connect the SCXI-1521/B.

NI-DAQmx 7.3 or later is required to configure and program the SCXI-1521/B module. If you do not have NI-DAQmx 7.3 or later, you can either contact an NI sales representative to request it on a CD or download the latest NI-DAQ version from `ni.com`.

Installing the SCXI-1521/B

Note Refer to the *Read Me First: Radio-Frequency Interference* document before removing equipment covers or connecting or disconnecting any signal wires.

Refer to the *SCXI Quick Start Guide* to unpack and install the SCXI-1521/B in an SCXI chassis. After installing the SCXI-1521/B, power on the SCXI chassis.

Connecting the SCXI-1521/B to an E/M Series DAQ Device for Multiplexed Scanning in a PXI/SCXI Combination Chassis

In this configuration, you can multiplex all 24 channels of the SCXI-1521/B into a single channel of the E/M Series DAQ device, in the right-most slot, using the PXI backplane in a PXI/SCXI combination chassis.

Consult the PXI/SCXI chassis documentation, the documentation of other SCXI modules, and E/M Series DAQ device documentation for additional instructions and cautions. You should have already installed your software,

and inserted the SCXI-1521/B module and any other SCXI modules in the chassis according to the instructions in the *SCXI Quick Start Guide*.

To use the SCXI-1521/B module in multiplexed mode with an E/M Series DAQ device in a PXI/SCXI combination chassis, complete the following steps:

Notes No cables are required between the SCXI-1521/B and the E/M Series DAQ device if the E/M Series DAQ device is installed in the right-most PXI slot. You can configure this device to control the SCXI system using an internal bus that connects the PXI chassis to the SCXI chassis.

When using the PXI-1011 combination chassis, you can only control the SCXI modules through the backplane. Parallel mode operation is not available with the PXI-1011 chassis and is not supported by the SCXI-1521/B.

1. Make sure the appropriate software is already installed or install it.
2. If the E/M Series DAQ device for controlling the SCXI system is not installed in the right-most slot of the PXI-1010 combination chassis, install it.
3. Power on the SCXI portion of the PXI combination chassis.

Refer to Chapter 3, *Configuring and Testing*, to configure the SCXI-1521/B.

Verifying and Self-Testing the Installation

To test the installation of the SCXI chassis, complete the following steps:

1. Verify that the chassis is powered on and correctly connected to an E/M Series DAQ device.
2. Launch MAX.
3. Display the list of devices and interfaces by clicking the **+** next to the **Devices and Interfaces** icon.
4. From the list that appears, locate the chassis you want to test. Right-click the chassis and select **Test**.
5. If the SCXI chassis is installed properly, a message indicating successful verification appears. Click **OK**.

The SCXI system should now operate properly with your ADE software. If the test did not complete successfully, refer to Chapter 3, *Configuring and Testing*, for troubleshooting steps.

If you are using NI-DAQmx, you can verify each module in the SCXI chassis. To test the successful installation of each module, complete the following steps:

1. Verify that the chassis is powered on and correctly connected to an E/M Series DAQ device.
2. Launch MAX.
3. Display the list of devices and interfaces by clicking the **+** next to the **Devices and Interfaces** icon.
4. From the list that appears, locate the chassis with the module you want to test.
5. Display the list of modules in the chassis by clicking the **+** next to the chassis with the module you want to test.
6. Right-click the module you want to test and select **Test Panels**.
7. If the **Error Details** box reads **`No Errors`**, you have successfully installed the module.

The SCXI system should now operate properly with your ADE software. If the test did not complete successfully, refer to Chapter 3, *Configuring and Testing*, for troubleshooting steps.

Troubleshooting the Self-Test Verification

If the Self-Test Verification did not verify the chassis configuration, complete the steps in this section to troubleshoot the SCXI configuration of NI-DAQmx.

- If you get a **Verify SCXI Chassis** message box showing the SCXI chassis model number, **Chassis ID: *x***, and one or more messages stating **Slot Number: *x* Configuration has module: SCXI-*XXXX*** or **1521/B, hardware in chassis is: Empty**, take the following troubleshooting actions:
  - Make sure the SCXI chassis is powered on.
  - Make sure all SCXI modules are properly installed in the chassis.
  - Make sure the cable between the SCXI chassis and E/M Series DAQ device is properly connected.
  - Inspect the cable connectors for bent pins.

  - Make sure you are using the correct NI cable assembly for your application.
  - Test the E/M Series DAQ device to verify it is working properly. Refer to the E/M Series DAQ device help file for more information.

- If you get a **Verify SCXI Chassis** message box showing the SCXI chassis model number, **Chassis ID: *x***, and the message **Slot Number: *x* Configuration has module: SCXI-*XXXX*** or **1521/B, hardware in chassis is: SCXI-*YYYY*, 1521/B**, or **Empty**, complete the following troubleshooting steps to correct the error.
  1. Expand the list of NI-DAQmx devices by clicking the **+** next to **NI-DAQmx Devices**.
  2. Right-click the SCXI chassis and click **Properties** to load the chassis configurator.
  3. Under the **Modules** tab, ensure that the cabled module is listed in the correct slot.
  4. If the cabled module is not listed in the correct slot, complete the following troubleshooting steps:
     a. If the cabled module is not listed in the correct slot and the slot is empty, click the drop-down listbox next to the correct slot and select the cabled module. Click **OK**.
     b. If another module appears where the cabled module should be, click the drop-down listbox next to the correct slot and select the cabled module. A message box appears asking you to confirm the module replacement. Click **OK**. Configure the cabled module. Click **OK**.
- Ensure that you have the highest priority SCXI module cabled to the E/M Series DAQ device. Refer to the *SCXI Quick Start Guide* to find out which SCXI module in the chassis should be cabled to the E/M Series DAQ device.
- After checking the preceding items, retest the SCXI chassis.

If these measures do not successfully configure the SCXI system, contact NI. Refer to the *Signal Conditioning Technical Support Information* document for contact information.

2

Connecting Signals

This chapter describes how to connect quarter-bridge strain gauges to the SCXI-1521/B through the SCXI-1317. It also provides the front and rear signal pin assignments of the module.

To connect a quarter-bridge strain gauge in configuration type I with either a 2- or 3-wire strain gauge, refer to the *SCXI-1317 Terminal Block Installation Guide*. Refer to Chapter 4, *Theory of Operation*, for a discussion of strain-gauge concepts.

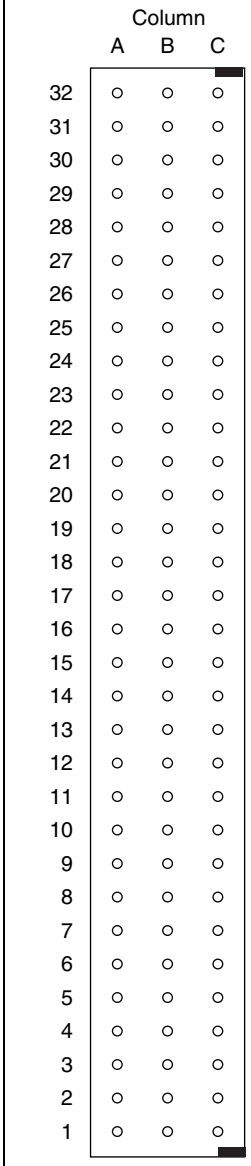
Pin Assignments

The pin assignments for the SCXI-1521/B front signal connector are shown in Table 2-1. The front signal connector is a special 96-pin DIN C male connector through which you make all signal connections. In the following list of terminal assignments *X* is the channel number:

- EX + *X* connects to the sensor excitation
- QTR *X* connects to the quarter-bridge completion resistor
- AI *X* connects to the amplifier terminal

The pins labeled RSVD are reserved. Do *not* make any connections to these pins.

Table 2-1. Front Signal Pin Assignments

Front Connector Diagram	Pin Number	Column A	Column B	Column C
	32	EX + 0	QTR 0	AI 0
	31	EX + 1	QTR 1	AI 1
	30	EX + 2	QTR 2	AI 2
	29	EX + 3	QTR 3	AI 3
	28	RSVD	QTR 4	AI 4
	27	RSVD	QTR 5	AI 5
	26	RSVD	EX + 4	RSVD
	25	RSVD	EX + 5	RSVD
	24	EX + 6	QTR 6	AI 6
	23	EX + 7	QTR 7	AI 7
	22	EX + 8	QTR 8	AI 8
	21	EX + 9	QTR 9	AI 9
	20	RSVD	QTR 10	AI 10
	19	RSVD	QTR 11	AI 11
	18	RSVD	EX + 10	RSVD
	17	RSVD	EX + 11	RSVD
	16	EX + 12	QTR 12	AI 12
	15	EX + 13	QTR 13	AI 13
	14	EX + 14	QTR 14	AI 14
	13	EX + 15	QTR 15	AI 15
	12	RSVD	QTR 16	AI 16
	11	RSVD	QTR 17	AI 17
	10	RSVD	EX + 16	RSVD
	9	RSVD	EX + 17	RSVD
	8	EX + 18	QTR 18	AI 18
	7	EX + 19	QTR 19	AI 19
	6	EX + 20	QTR 20	AI 20
	5	EX + 21	QTR 21	AI 21
	4	RSVD	QTR 22	AI 22
	3	RSVD	QTR 23	AI 23
	2	RSVD	EX + 22	RSVD
	1	RSVD	EX + 23	RSVD

The rear signal connector is a 50-pin male cable connector used for analog signal connectivity and communication between the SCXI-1521/B and the connected E/M Series DAQ device. Table 2-2 shows the rear signal connector and lists the pin assignments for the SCXI-1521/B. Grounding signals AI GND and OUT REF provide reference signals needed in the various analog input referencing modes on the E/M Series DAQ device.

Table 2-2. Rear Signal Pin Assignments

Rear Connector Diagram	Signal Name	Pin Number	Pin Number	Signal Name
	AI GND	1	2	AI GND
	AI 0 +	3	4	AI 0 –
	—	5	6	—
	—	7	8	—
	—	9	10	—
	—	11	12	—
	—	13	14	—
	—	15	16	—
	—	17	18	—
	OUT REF	19	20	—
	—	21	22	—
	—	23	24	DIG GND
	SER DAT IN	25	26	SER DAT OUT
	DAQ D*/A	27	28	—
	SLOT 0 SEL*	29	30	—
	—	31	32	—
	DIG GND	33	34	—
	—	35	36	AI HOLD COMP, AI HOLD
	SER CLK	37	38	—
	—	39	40	—
	—	41	42	—
	—	43	44	—
	—	45	46	SYNC
	—	47	48	—
	—	49	50	—

In multiplexed mode, the AI 0 signal pair is used for sending all 24 channels of the SCXI-1521/B, and analog signals from other modules, to the connected E/M Series DAQ device. If the module is cabled directly to the E/M Series DAQ device, the other analog channels of the E/M Series DAQ device are unavailable for general-purpose analog input because they are connected to active signals on the SCXI-1521/B amplifier.

Table 2-3 lists the communication signals between the E/M Series DAQ device and the SCXI system. If the E/M Series DAQ device is connected to the SCXI-1521/B, these digital lines are unavailable for general-purpose digital I/O.

Table 2-3. SCXI-1521/B Communication Signals

Pin	SCXI Signal Name	NI-DAQmx Device Signal Name	Direction	Description
24, 33	DIG GND	D GND	—	Digital ground—These pins supply the reference for E/M Series DAQ device digital signals and are connected to the module digital ground.
25	SER DAT IN	P0.0	Input	Serial data in—This signal taps into the SCXIbus MOSI line to send serial input data to a module or Slot 0.
26	SER DAT OUT	P0.4	Output	Serial data out—This signal taps into the SCXIbus MISO line to accept serial output data from a module.
27	DAQ D*/A	P0.1	Input	Board data/address line—This signal taps into the SCXIbus D*/A line to indicate to the module whether the incoming serial stream is data or address information.
29	SLOT 0 SEL*	P0.2	Input	Slot 0 select—This signal taps into the SCXIbus INTR* line to indicate whether the information on MOSI is being sent to a module or Slot 0.

Table 2-3. SCXI-1521/B Communication Signals (Continued)

Pin	SCXI Signal Name	NI-DAQmx Device Signal Name	Direction	Description
36	SCAN CLK	AI HOLD COMP, AI HOLD	Input	Scan clock—A rising edge indicates to the scanned SCXI module that the E/M Series DAQ device has taken a sample and causes the module to advance channels.
37	SER CLK	EXTROBE*	Input	Serial clock—This signal taps into the SCXIbus SPI CLK line to clock the data on the MOSI and MISO lines.

3

Configuring and Testing

This chapter describes how to configure the SCXI-1521/B in MAX for use with NI-DAQmx. It also describes how to create and test a virtual channel, global channel, and/or task.

SCXI-1521/B Software Configurable Settings

This section describes how to set the voltage excitation level, and gain/input signal range, as well as how to use configuration utilities in MAX to programmatically perform offset null compensation and shunt calibration. It also describes how to perform configuration of these settings for the SCXI-1521/B in NI-DAQmx. For more information about the relationship between the settings and the measurements and how to configure settings in your application, refer to Chapter 4, *Theory of Operation*.

Common Software-Configurable Settings

This section describes the most frequently used software configurable settings for the SCXI-1521/B. Refer to Chapter 4, *Theory of Operation*, for a complete list of software configurable settings.

Bridge Configuration

Bridge configuration is a software configurable setting that allows you to easily configure the bridge type. The SCXI-1521/B only supports the quarter-bridge I strain-gauge bridge configuration.

Excitation Level

Excitation level is a software configurable setting that allows you to set the excitation voltage level of the module. You can choose voltage excitation settings between 0 and 5 V in 1,023 increments.

Refer to Appendix A, *Specifications*, for more information about the excitation voltage settings on the SCXI-1521/B.

Gain/Input Range

Gain/input range is a software-configurable setting that allows you to choose the appropriate amplification for your application. The SCXI-1521/B has a fixed gain of 42 V/V. Additional gain settings are available on the digitizer device. In most applications NI-DAQmx selects the gain for you based on the specified input range.

Fine Null Potentiometer

The fine null potentiometer has software configurable settings that allow you to remove unwanted offset voltage. In most cases, you do not explicitly set the fine null potentiometer, but instead allow driver software to automatically adjust it for you. However, if you want to explicitly set the fine null potentiometer, you can write an application program that adjusts the fine null potentiometer settings. Refer to Chapter 4, *Theory of Operation*, for more information.

Shunt Calibration Switches

The SCXI-1521/B includes a software controllable shunt calibration switch on each channel of the module that is used to engage or disengage a fixed shunt calibration resistor.

Note The gain adjustment is done for you automatically if you have performed shunt calibration using the NI-DAQ driver. Refer to the *NI-DAQmx* section for more information about how to perform shunt calibration using the driver.

Modes of Operation

The SCXI-1521/B operates in multiplexed mode only.

Configurable Settings in MAX

Note If you are using an NI ADE prior to version 7.0, are using an unlicensed copy of an NI ADE, or are not using an NI ADE, additional dialog boxes from the NI License Manager appear allowing you to create a task or global channel in unlicensed mode. These messages continue to appear until you install version 7.0 or later of an NI ADE.

This section describes where to access each software-configurable setting for modification in MAX. The location of the settings varies depending on the version of NI-DAQ you use. Refer to the *NI-DAQmx* section for more information about setting locations.

NI-DAQmx

Note All software configurable settings are not configurable both ways. This section only discusses settings in MAX. Refer to Chapter 4, *Theory of Operation*, for information about using functions in your application.

Strain and custom voltage with excitation are the most commonly used NI-DAQmx task or NI-DAQmx Global Channel types with the SCXI-1521/B. The following list describes the settings you can use in MAX and where they are located:

- Voltage excitation—configure using either **NI-DAQmx Task** or **NI-DAQmx Global Channel**. You can also set the voltage excitation level through your application. In NI-DAQmx, you can choose from contiguous voltages between 0 and 5 V. The default voltage excitation in NI-DAQmx is 0 V.
- Input signal range—configure the input signal range using either **NI-DAQmx Task** or **NI-DAQmx Global Channel**. When you set the minimum and maximum range of **NI-DAQmx Task** or **NI-DAQmx Global Channel**, the driver selects the best gain for the measurement.
- Calibration settings—fine null potentiometer settings and control shunt calibration switches only using **Strain NI-DAQmx Task**, **Strain NI-DAQmx Global Channel**, or your application. The **Custom Voltage with Excitation NI-DAQmx Task** or **NI-DAQmx Global Channel** cannot adjust calibration settings in MAX. Adjust calibration settings in your application. The default configuration settings set the fine null potentiometer to 2,048, which is its midrange value. The default state of the shunt calibration switches is open. This state leaves the shunt calibration resistor disconnected from the circuit.
- Modes of operation—refer to Chapter 1, *About the SCXI-1521/B*, for more information about chassis installation. The default setting in NI-DAQmx is multiplexed.

Creating a Strain Global Channel or Task

To create a new NI-DAQmx strain global task or channel, complete the following steps:

1. Launch MAX.
2. Right-click **Data Neighborhood**, and select **Create New**.
3. Select **NI-DAQmx Task** or **NI-DAQmx Global Channel**, and click **Next**.
4. Select **Analog Input**.

5. Select **Strain**.
6. If you are creating a task, you can select a range of channels by holding down the <Shift> key while selecting the channels. You can select multiple individual channels by holding down the <Ctrl> key while selecting channels. If you are creating a channel, you can only select one channel. Click **Next**.
7. Name the task or channel, and click **Finish**.
8. In the box labelled **Channel List**, select the channel(s) you want to configure. You can select a range of channels by holding down the <Shift> key while selecting the channels. You can select multiple individual channels by holding down the <Ctrl> key while selecting channels.

Note To add channels from another module measuring strain, first complete the task creation for one module, and then in the **Channel List**, select the **+** to add channels to the strain task. Add the additional channels to your task. To add channels of various measurement types to the same task, you must complete this task in your application. Refer to the *Developing Your Application in NI-DAQmx* section of Chapter 5, *Using the SCXI-1521/B*, for more information about adding channels.

9. Enter the specific values for your application in the **Settings** tab. Context help information for each setting is provided on the right side of the screen.
10. Ensure that you have selected the strain channel(s) you wish to calibrate in the **Channel List** box. Click **Calibration** to calibrate the strain channel(s).
11. On the screen that opens, choose to enable offset nulling and/or shunt calibration. Enter the shunt calibration resistor information. Click **Next**.
12. **Measure and Calibrate** displays information specific to the strain channel(s). Click **Measure** to acquire a signal from the strain channel(s) and **Reset Data** to reset the values to default. Click **Calibrate** to calibrate the strain channel(s). When you have completed calibrating the strain channel(s), click **Finish**.
13. If you are creating a task and want to set timing or triggering controls, enter the values in the **Task Timing** and **Task Triggering** tabs.

Verifying the Signal

This section describes how to take measurements using test panels in order to verify signal, and configuring and installing a system in NI-DAQmx.

Verifying the Signal in NI-DAQmx Using a Task or Global Channel

Complete the following steps to verify the SCXI-1521/B signals:

1. Open the channel or task you created in the *Creating a Strain Global Channel or Task* section.
2. Click the **Test** button.

4

Theory of Operation

This chapter discusses strain-gauge concepts and the theory of operational measurement concepts.

Strain-Gauge Theory

This section describes how to arrange, connect, and scale signals from bridge-based sensors—especially strain gauges.

Wheatstone Bridges

All strain-gauge configurations are based on the concept of a Wheatstone bridge. A Wheatstone bridge is a network of four resistive legs. One or more of these legs can be an active sensing element. Figure 4-1 shows a Wheatstone bridge circuit diagram.

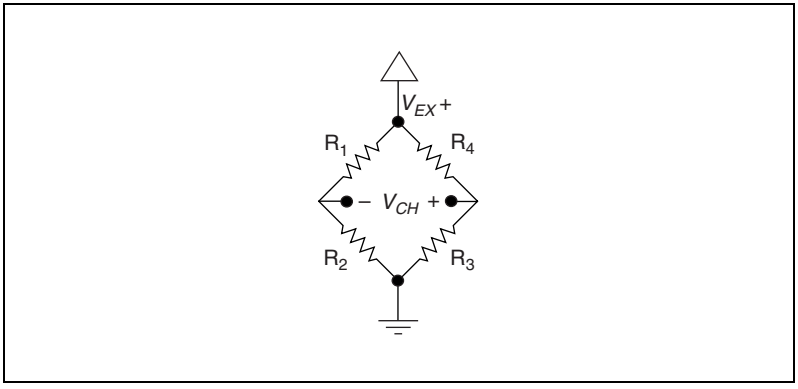


Figure 4-1. Basic Wheatstone Bridge Circuit Diagram

The Wheatstone bridge is the electrical equivalent of two parallel voltage divider circuits. R_1 and R_2 compose one voltage divider circuit, and R_4 and R_3 compose the second voltage divider circuit. The output of a Wheatstone bridge is measured between the middle nodes of the two voltage dividers.

A physical phenomenon, such as a change in strain or temperature applied to a specimen, changes the resistance of the sensing elements in the

Wheatstone bridge. The Wheatstone bridge configuration is used to help measure the small variations in resistance that the sensing elements produce in response to a physical changes in the specimen.

Acronyms, Formulas, and Variable Definitions

In the figures and equations in this document, the acronyms, formulas, and variables are defined as:

ε is the measured strain (+ε is tensile strain and –ε is compressive strain).

ε_S is the simulated strain.

GF is the Gauge Factor, which should be specified by the gauge manufacturer.

R_g is the nominal gauge resistance, which should be specified by the gauge manufacturer.

R_L is the lead resistance. If lead lengths are long, R_L can significantly affect measurement accuracy.

R_s is the shunt calibration resistor value.

U is the ratio of expected signal voltage to excitation voltage with the shunt calibration circuit engaged. Parameter *U* appears in the equations for simulated strain and is defined by the following equation:

$$U = \frac{-R_g}{4R_s + 2R_g}$$

ν is the Poisson's ratio, defined as the negative ratio of transverse strain to axial strain (longitudinal) strain. Poisson's ratio is a material property of the specimen you are measuring.

V_{CH} is the measured voltage of the signal.

V_{EX} is the excitation voltage.

V_r is the voltage ratio that is used in the voltage to strain conversion equations and is defined by the following equation:

$$V_r = \left(\frac{V_{CH}(\text{strained}) - V_{CH}(\text{unstrained})}{V_{EX}}\right)$$

Software Scaling and Equations

Once you have acquired the voltage signal V_{CH}, you can scale this voltage to the appropriate strain units in software. This is done automatically for you in NI-DAQmx using a strain task or strain channel. You can also scale the voltages manually in your application using the voltage to strain conversion equations provided in this document for each configuration type.

Finally, voltage to strain conversion functions are included in LabVIEW and NI-DAQmx. In LabVIEW, the conversion function, Convert Strain Gauge Reading.vi, is in the **Data Acquisition»Signal Conditioning** subpalette. The prototypes for the NI-DAQ functions, `Strain_Convert` and `Strain_Buf_Convert`, are in the header file `convert.h` for C/C++, and `convert.bas` for Visual Basic.

The names of the strain-gauge types in these sections directly correspond to bridge selections in MAX and the LabVIEW Convert Strain Gauge Reading VI.

Quarter-Bridge Type I

This section provides information about the quarter-bridge strain-gauge configuration type I. The quarter-bridge type I measures either axial or bending strain. Figure 4-2 shows how to position a strain-gauge resistor in an axial and bending configurations. Figure 4-3 shows the quarter-bridge type I circuit wiring diagram.

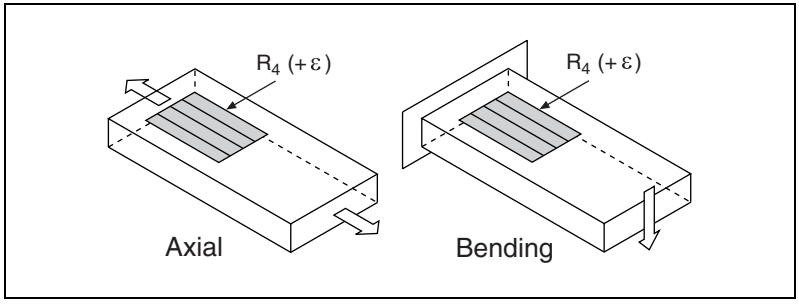


Figure 4-2. Quarter-Bridge Type I Measuring Axial and Bending Strain

A quarter-bridge type I has the following characteristics:

- A single active strain-gauge element is mounted in the principle direction of axial or bending strain.
- A passive quarter-bridge completion resistor (dummy resistor) is required in addition to half-bridge completion.

- Temperature variation in specimen decreases the accuracy of the measurements.
- Sensitivity at 1000 με, where GF = 2.0, is ~ 0.5 mV_{out} / V_{EX} input.

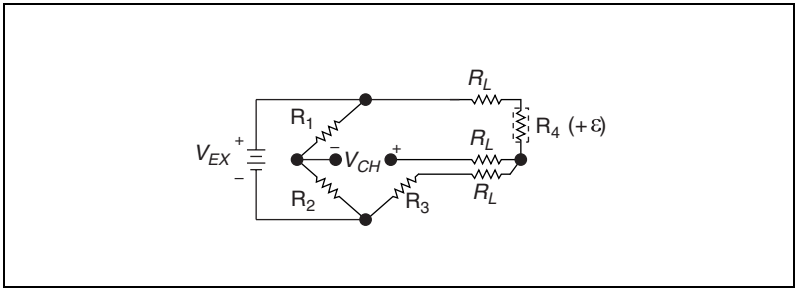


Figure 4-3. Quarter-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

R_1 and R_2 are half-bridge completion resistors.

R_3 is the quarter-bridge completion resistor (dummy resistor).

R_4 is the active strain-gauge element measuring tensile strain (+ε).

V_{EX} is the excitation voltage.

R_L is the lead resistance.

V_{CH} is the measured voltage.

V_r is the voltage ratio that is used in the voltage to strain conversion equations and is defined by the following equation:

$$V_r = \left(\frac{V_{CH}(\text{strained}) - V_{CH}(\text{unstrained})}{V_{EX}}\right)$$

To convert voltage readings to strain units use, the following equation:

$$strain\ (\varepsilon) = \frac{-4V_r}{GF(1+2V_r)} \times \left(1 + \frac{R_L}{R_g}\right)$$

where R_g is the nominal gauge resistance of the sensor.

R_L is the lead resistance.

GF is the Gauge Factor.

To simulate the effect on strain of applying a shunt resistor across R_3, use the following equation:

$$\varepsilon_s = \frac{-4U}{GF(1+4U)}$$

Notes To minimize temperature drift errors, the strain gauge must have a self-temperature-compensation (STC) number that corresponds to the thermal expansion coefficient of the material under test. STC gauges have a temperature sensitivity that counteracts the thermal expansion coefficient of the test specimen. The STC number approximately equals the thermally induced change in strain with change in temperature and is expressed in units of microstrain per degree Fahrenheit. For example, if the test specimen is aluminum, use a gauge with an STC number of 13.0. If the test specimen is steel, use a gauge with an STC number of 6.0.

You can neglect lead resistance (R_L) of the wiring if shunt calibration is performed or if lead length is very short (~ <10 ft), depending on the wire gauge. For example 10 ft of 24-AWG copper wire has a lead resistance of 0.25 Ω.

SCXI-1521/B Theory of Operation

This section includes a brief overview and a detailed discussion of the circuit features of the module. Refer to Figure 4-4 while reading this section.

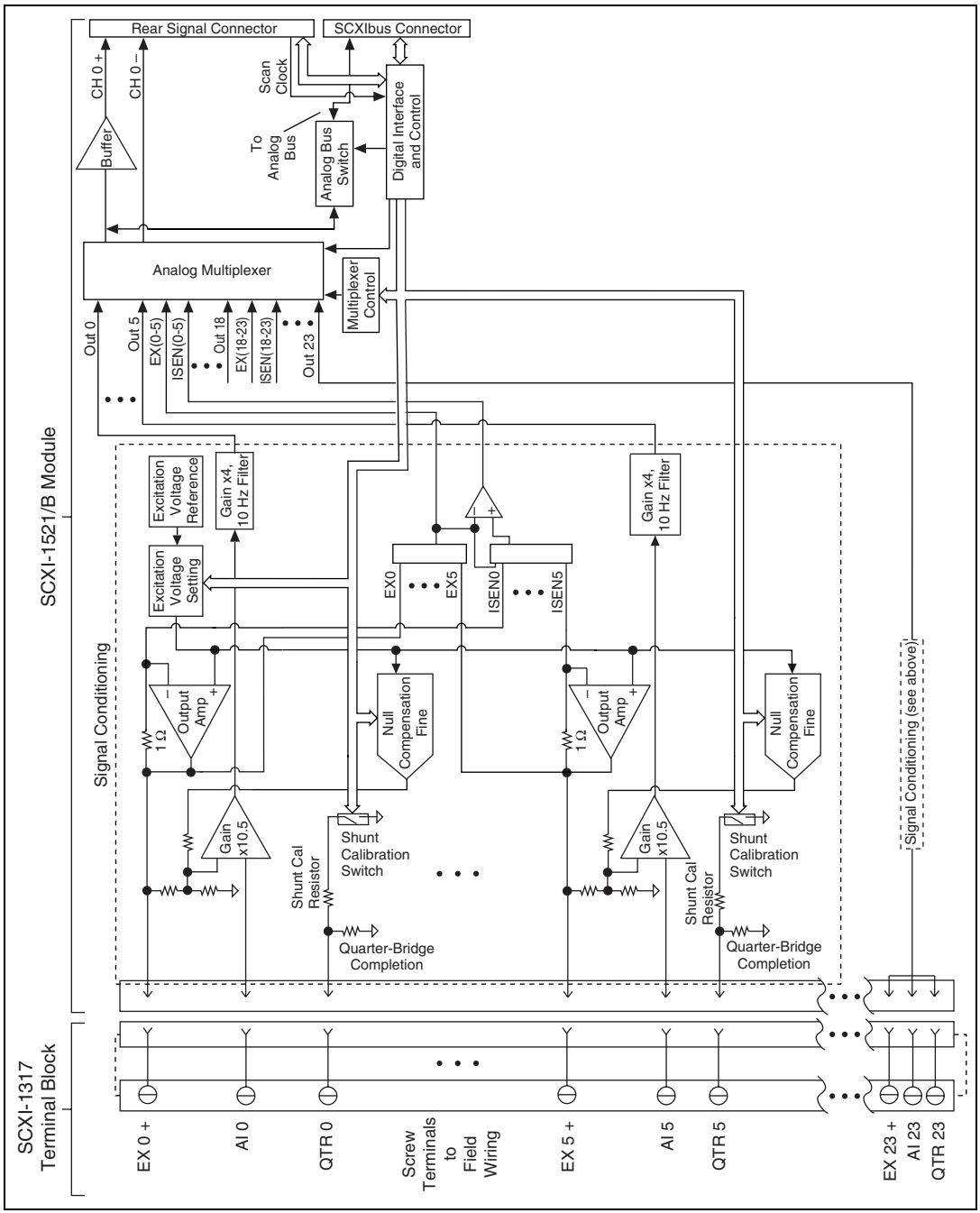


Figure 4-4. Block Diagram of SCXI-1317 and SCXI-1521/B Combination

The SCXI-1521/B input terminals consist of three terminals per channel for direct connectivity to 3-wire resistive strain gauges. EX+ connects to the voltage excitation, QTR connects to the SCXI-1521/B quarter-bridge completion resistor, and AI connects to the SCXI-1521/B AI input amplifier. Figure 4-4 shows the block diagram of the SCXI-1521/B.

The input amplifier stage provides amplification and presents a high input impedance to external signals. The offset null compensation circuitry is used to null offset voltages that result from initial imbalances in the strain-gauge bridge connection.

The input amplification stage is followed by an additional amplification and lowpass filter stage before reaching the output multiplexer.

The SCXI-1521/B has a fixed lowpass filter with a 3 dB cutoff of 10 Hz.

The SCXI-1521/B has a fixed gain of 42 V/V.

The signal then passes to the multiplexer stage. The modes of operation are determined by the multiplexer stage. The signal is routed to the E/M Series DAQ device channel 0 if the SCXI-1521/B is the cabled module and/or to the SCXI backplane through the SCXIbus connector.

Note The SCXI-1521/B does not support parallel mode.

The multiplexer stage is controlled by the digital interface and control circuitry. The digital interface and control circuitry stores the scan list, controls the multiplexer, and allows flexible scanning (random scanning).

The shunt calibration circuitry is comprised of a fixed value shunt resistor in series with a switch. The switch is controlled by the digital interface and control circuity. When the switch is closed, the shunt calibration resistor is connected in parallel with the quarter-bridge completion resistor.

For more detailed information about the operation of any of these circuitry stages, refer to the *Quarter-Bridge Completion*, *Excitation*, *Offset Null Compensation*, *Shunt Calibration*, and *Modes of Operation* sections.

Quarter-Bridge Completion

Quarter-bridge completion resistors are provided on the module. The SCXI-1521 has 350 Ω resistors, while the SCXI-1521B has 120 Ω resistors.

Excitation

You can set the excitation voltage of the SCXI-1521/B from 0 to 5 V in 1,023 steps. The excitation voltage is buffered on a per channel basis to prevent excitation load variation errors from interfering with other channels. You can set the excitation voltage in banks of six channels grouped as follows: CH <0..5>, CH <6..11>, CH <12..17>, and CH <18..23>.

Refer to the *Configurable Settings in MAX* section of Chapter 3, *Configuring and Testing*, for more information about programmatically setting excitation level in MAX. For more information about programmatically setting excitation level in NI-DAQmx, refer to the *Developing Your Application in NI-DAQmx* section of Chapter 5, *Using the SCXI-1521/B*.

Offset Null Compensation

The SCXI-1521/B provides hardware offset null compensation that removes the offset voltage that exists in the strain gauge when it is unstrained to adjust signal voltages to proper levels. Hardware offset nulling is performed programmatically using software.

The fine null potentiometer is used for offset adjustments. The potentiometer signals are added to the analog input path to adjust the signal voltage to remove the offset, which nulls the strain-gauge channel. The voltage input to the potentiometer is a voltage proportional to the excitation voltage setting. Therefore, if the excitation voltage changes by a small amount due to a changes such as temperature and sensor loading, the correction signal produced by the fine null potentiometer changes by the same amount and the offset null is maintained.

The fine null potentiometer is controlled digitally using control codes. The control codes of the fine null potentiometer are set in software using integer values. Table 4-1 summarizes the nulling range and scale of the control codes.

Table 4-1. Control Codes for Fine Null Potentiometers

Range (Integer Values)	Mid-Scale	Bridge Offset Nulling
0 to 4,095	2,048	±0.45% of V_{EX}

In most cases, you do not explicitly set the fine null potentiometer, but instead allow the NI-DAQ driver software to automatically adjust it for you. You can do this either through MAX or in your application.

Refer to the *Configurable Settings in MAX* section of Chapter 3, *Configuring and Testing*, for more information about programmatically performing offset null compensation in MAX. For more information about programmatically performing offset null compensation in NI-DAQmx, refer to the *Developing Your Application in NI-DAQmx* section of Chapter 5, *Using the SCXI-1521/B*.

Shunt Calibration

Shunt calibration is a process used to obtain a gain adjust factor, which is used to correct for system gain error.

The gain adjust factor is derived using theoretical (simulated) signal levels that should result from engaging a shunt resistor across one leg of a bridge sensor and the measured signal levels with the shunt resistor actually engaged.

Use the following formula to calculate the gain adjust factor:

$$\textit{gain adjust factor} = \frac{\textit{simulated signal level}}{\textit{measured signal level with shunt resistor engaged}}$$

The gain adjust factor is then multiplied by each future measurement to obtain accurate measurements that are adjusted for gain errors. Refer to the *Configurable Settings in MAX* section of Chapter 3, *Configuring and Testing*, for more information about performing shunt calibration automatically in global channels using NI-DAQmx in MAX. For more information about programmatically performing shunt calibration in NI-DAQmx, refer to the *Developing Your Application in NI-DAQmx* section of Chapter 5, *Using the SCXI-1521/B*.

Note Perform an offset null compensation just before you perform a shunt calibration. Performing a shunt calibration before an offset null compensation causes improper gain adjustment because the offset signal voltage is compensated multiple times.

Modes of Operation

The SCXI-1521/B operates in multiplexed mode, passing the conditioned signals to the digitizing DAQ device.

Theory of Multiplexed Mode Operation

In multiplexed mode, all input channels of an SCXI module are multiplexed into a single analog input channel of the DAQ device. Multiplexed mode operation is ideal for high channel count systems. Multiplexed mode is typically used for performing scanning operations with the SCXI-1521/B. The power of SCXI multiplexed mode scanning is its ability to route many input channels to a single channel of the DAQ device.

The multiplexing operation of the analog input signals is performed entirely by multiplexers in the SCXI modules, not inside the DAQ device or SCXI chassis. In multiplexed mode the SCXI-1521/B scanned channels are kept by the NI-DAQ driver in a scan list. Immediately prior to a multiplexed scanning operation, the SCXI chassis is programmed with a module scan list that controls which module sends its output to the SCXIbus during a scan through the cabled SCXI module.

The list can contain channels in any physical order and the multiplexer can sequence the channel selection from the scan list in any order. The ordering of scanned channels need not be sequential. Channels can occur multiple times in a single scan list. The scan list can contain an arbitrary number of channels for each module entry in the scan list, limited to a total of 512 channels per DAQ device. This is referred to as flexible scanning (random scanning). Not all SCXI modules provide flexible scanning.

The module includes first-in first-out (FIFO) memory for storing the channel scan list defined in your application code. NI-DAQ drivers load the FIFO based on the channel assignments you make in your application. You need not explicitly program the module FIFO as this is done automatically for you by the NI-DAQ driver.

When you configure a module for multiplexed mode operation, the routing of multiplexed signals to the DAQ device depends on which module in the SCXI system is cabled to the DAQ device. There are several possible scenarios for routing signals from the multiplexed modules to the DAQ device.

If the scanned SCXI-1521/B module is not directly cabled to the DAQ device, the module sends its signals through the SCXIbus to the cabled module. The cabled module, whose routing is controlled by the SCXI chassis, routes the SCXIbus signals to the DAQ device through the AI 0 pin on its rear signal connector.

If the DAQ device scans the cabled module, the module routes its input signals through the AI 0 pin on its rear signal connector to the DAQ device AI 0.

5

Using the SCXI-1521/B

This chapter makes suggestions for developing your application and provides basic information regarding calibration.

Developing Your Application in NI-DAQmx

Note If you are using an NI ADE prior to version 7.0, using an unlicensed copy of an NI ADE, or not using an NI ADE, additional dialog boxes from the NI License Manager appear allowing you to create a task or global channel in unlicensed mode. These messages continue to appear until you install version 7.0 or later of an NI ADE.

This section describes how to configure and use NI-DAQmx to control the SCXI-1521/B in LabVIEW, LabWindows/CVI, and Measurement Studio. These ADEs provide greater flexibility and access to more settings than MAX, but you can use ADEs in conjunction with MAX to quickly create a customized application.

Typical Program Flowchart

Figure 5-1 shows a typical program flowchart for creating a task to configure channels, take a measurement, analyze the data, present the data, stop the measurement, and clear the task.

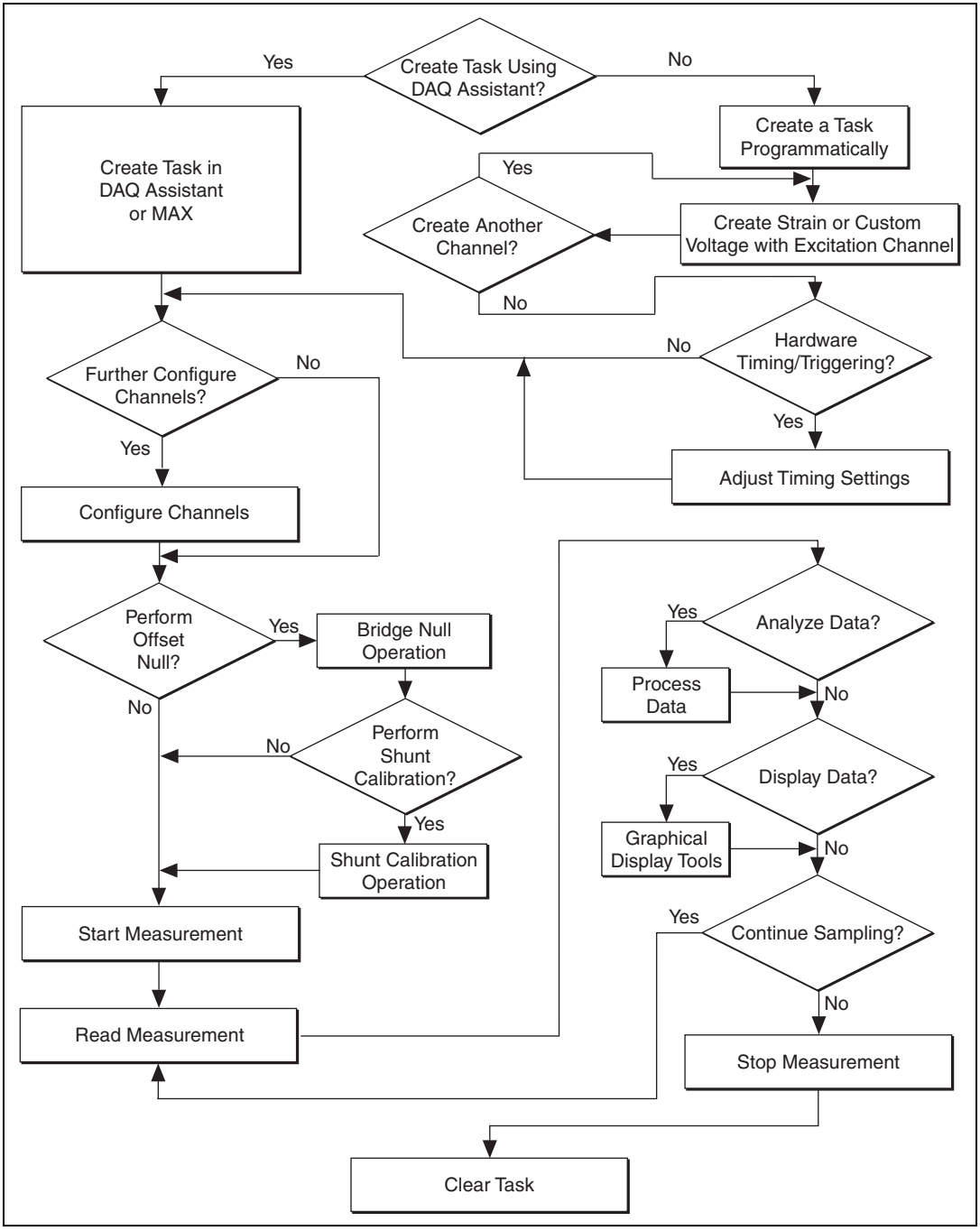


Figure 5-1. Typical Program Flowchart

General Discussion of Typical Flow Chart

The following sections briefly discuss some considerations for a few of the steps in Figure 5-1. These sections are meant to give an overview of some of the options and features available when programming with NI-DAQmx.

Creating a Task Using DAQ Assistant or Programmatically

When creating an application, you must first decide whether to create the appropriate task using the DAQ Assistant or programmatically in the ADE.

Developing your application using DAQ Assistant gives you the ability to configure most settings such as measurement type, selection of channels, excitation voltage, signal input limits, task timing, and task triggering. You can access the DAQ Assistant through MAX or your NI ADE. Choosing to use the DAQ Assistant can simplify the development of your application. NI recommends creating tasks using the DAQ Assistant for ease of use, when using a sensor that requires complex scaling, or when many properties differ between channels in the same task.

If you are using an ADE other than an NI ADE, or if you want to explicitly create and configure a task for a certain type of acquisition, you can programmatically create the task from your ADE using functions or VIs. If you create a task using the DAQ Assistant, you can still further configure the individual properties of the task programmatically with functions or property nodes in your ADE. NI recommends creating a task programmatically if you need explicit control of programmatically adjustable properties of the DAQ system.

Programmatically adjusting properties for a task created in the DAQ Assistant overrides the original, or default, settings only for that session. The changes are not saved to the task configuration. The next time you load the task, the task uses the settings originally configured in the DAQ Assistant.

Adjusting Timing and Triggering

There are several timing properties that you can configure through the DAQ Assistant or programmatically using function calls or property nodes. If you create a task in the DAQ Assistant, you can still modify the timing properties of the task programmatically in your application.

When programmatically adjusting timing settings, you can set the task to acquire continuously, acquire a buffer of samples, or acquire one point at a

time. For continuous acquisition, you must use a while loop around the acquisition components even if you configured the task for continuous acquisition using MAX or the DAQ Assistant. For continuous and buffered acquisitions, you can set the acquisition rate and the number of samples to read in the DAQ Assistant or programmatically in your application. By default, the clock settings are automatically set by an internal clock based on the requested sample rate. You can also select advanced features such as clock settings that specify an external clock source, internal routing of the clock source, or select the active edge of the clock signal.

Configuring Channel Properties

All ADEs used to configure the SCXI-1521/B access an underlying set of NI-DAQmx properties. Table 5-1 shows some of these properties. You can use Table 5-1 to determine what kind of properties you need to set to configure the module for your application. For a complete list of NI-DAQmx properties, refer to your ADE help file.

Note You cannot adjust some properties while a task is running. For these properties, you must stop the task, make the adjustment, and re-start the application. Figure 5-1 assumes all properties are configured before the task is started.

Table 5-1. NI-DAQmx Properties

Property	Short Name	Description
Analog Input»General Properties» Advanced»Range»High	AI.Rng.High	Specifies the upper limit of the input range
Analog Input»General Properties» Advanced»Range»Low	AI.Rng.Low	Specifies the lower limit of the input range
Analog Input»General Properties» Signal Conditioning»Bridge» Shunt Cal»Shunt Cal Enable	AI.Bridge.ShuntCal.Enable	Specifies whether to place the shunt calibration resistor across one arm of the bridge
Analog Input»General Properties» Signal Conditioning»Excitation» Value	AI.Excit.Val	Specifies the amount of excitation in volts
Analog Input»General Properties» Signal Conditioning»Bridge» Nominal Resistance	AI.Bridge.NomResistance	Specifies in ohms the resistance of the bridge in an unloaded condition

Table 5-1. NI-DAQmx Properties (Continued)

Property	Short Name	Description
Analog Input»Strain»Strain Gage» Gage Factor	AI.StrainGage.GageFactor	Specifies the sensitivity of the strain gauge
Analog Input»Strain»Strain Gage» Poisson Ration	AI.StrainGage.PoissonRatio	Specifies the ratio of lateral strain to axial strain in the specimen material
Analog Input»General Properties» Signal Conditioning»Bridge» Initial Bridge Voltage	AI.Bridge.InitialVoltage	Specifies in volts the output voltage of the bridge in the unloaded condition
Analog Input»General Properties» Signal Conditioning»Bridge» Balance»Fine Potentiometer Property	AI.Bridge.Balance.FinePot	Specifies by how much to compensate for offset in the signal. This value can be between 0 and 4,095.
Analog Input»General Properties» Signal Conditioning»Excitation» Source	AI.Excit.Src	Specifies the source of excitation

Note This is *not* a complete list of NI-DAQmx properties and does not include every property you may need to configure your application. It is a representative sample of important properties to configure for strain measurements. For a complete list of NI-DAQmx properties and more information about NI-DAQmx properties, refer to your ADE help file.

Perform Offset Null Compensation

The SCXI-1521/B provides offset null compensation circuitry to adjust signal voltages to proper levels when the strain gauge is at rest (unstrained). You can use a strain task or global channel to perform offset null compensation. The offset null compensation is performed during the configuration of the global channel(s). Refer to the *Creating a Strain Global Channel or Task* section of Chapter 3, *Configuring and Testing*, for information about offset null compensation when in MAX.

For more information about offset null compensation, refer to the *Offset Null Compensation* section of Chapter 4, *Theory of Operation*.

Perform Shunt Calibration

Shunt calibration is a process used to obtain a gain adjust factor, which corrects for system gain error. You can use a strain task or global channel to perform shunt calibration. The shunt calibration is performed during the configuration of the global channel(s). Refer to the *Creating a Strain Global Channel or Task* section of Chapter 3, *Configuring and Testing*, for information about shunt calibration in MAX.

To manually perform shunt calibration, refer to the *Shunt Calibration* section of Chapter 4, *Theory of Operation*.

Acquiring, Analyzing, and Presenting

After configuring the task and channels, you can start the acquisition, read measurements, analyze the data returned, and display it according to the needs of your application. Typical methods of analysis include digital filtering, averaging data, performing harmonic analysis, applying a custom scale, or adjusting measurements mathematically.

Some custom scaling applications require the actual excitation voltage applied to the bridge instead of the nominal excitation voltage output by the SCXI-1521/B.

NI provides powerful analysis toolsets for each NI ADE to help you perform advanced analysis on the data without requiring you to have a programming background. After you acquire the data and perform any required analysis, it is useful to display the data in a graphical form or log it to a file. NI ADEs provide easy to use tools for graphical display, such as charts, graphs, slide controls, and gauge indicators. NI ADEs have tools that allow you to easily save the data to files such as spread sheets for easy viewing, ASCII files for universality, or binary files for smaller file sizes.

Completing the Application

After you have completed the measurement, analysis, and presentation of the data, it is important to stop and clear the task. This releases any memory used by the task and frees up the DAQ hardware for use in another task.

Developing an Application Using LabVIEW

This section describes in more detail the steps shown in the typical program flowchart in Figure 5-1, such as how to create a task in LabVIEW and configure the channels of the SCXI-1521/B. If you need more information or for further instructions, select **Help»VI, Function, & How-To Help** from the LabVIEW menu bar.

Note Except where otherwise stated, the VIs in Table 5-2 are located on the **Functions» All Functions»NI Measurements»DAQmx - Data Acquisition** subpalette and accompanying subpalettes in LabVIEW.

Table 5-2. Programming a Task in LabVIEW

Flowchart Step	VI or Program Step
Create Task in DAQ Assistant	Create a `DAQmx Task Name Constant` located on the **Controls»All Controls»I/O»DAQmx Name Controls** subpalette, right-click it, and select `New Task (DAQ Assistant)`.
Create a Task Programmatically (optional)	`DAQmx Create Task.vi`—This VI is optional if you created and configured your task using the DAQ Assistant. However, if you use it in LabVIEW any changes you make to the task will not be saved to a task in MAX.
Create AI Strain Channel (optional) or Create AI Custom Voltage with Excitation Channel	`DAQmx Create Virtual Channel.vi` (AI Voltage by default, to change to a strain gauge channel click **AI Voltage** and select **Analog Input»Strain»Strain Gage**.)—This VI is optional if you created and configured your task and channels using the DAQ Assistant. Any channels created with this VI are not saved in the task in the DAQ Assistant, they are only available for the present session.
Adjust Timing Settings (optional)	`DAQmx Timing.vi` (Sample Clock by default)—This VI is optional if you created and configured your task using the DAQ Assistant. Any timing settings modified with this VI are not saved in the task in the DAQ Assistant, they are only available for the present session.

Table 5-2. Programming a Task in LabVIEW (Continued)

Flowchart Step	VI or Program Step
Configure Channels (optional)	DAQmx Channel Property Node, refer to the *Using a DAQmx Channel Property Node in LabVIEW* section for more information. This step is optional if you created and fully configured the channels in your task using the DAQ Assistant. Any channel modifications made with a channel property node are not saved in the task in the DAQ Assistant, they are only available for the present session.
Perform Offset Null Compensation	You can perform offset null compensation when you create and configure your channels using the DAQ Assistant. Refer to the *Creating a Strain Global Channel or Task* section of Chapter 3, *Configuring and Testing*, for information about offset null compensation in MAX.
Perform Shunt Calibration	You can perform shunt calibration when you create and configure your channels using the DAQ Assistant. Refer to the *Creating a Strain Global Channel or Task* section of Chapter 3, *Configuring and Testing*, for information about shunt calibration in MAX.
Start Measurement	`DAQmx Start Task.vi`
Read Measurement	`DAQmx Read.vi`
Analyze Data	Some examples of data analysis include filtering, scaling, harmonic analysis, or level checking. Some data analysis tools are located on the **Functions»Signal Analysis** subpalette and on the **Functions»All Functions»Analyze** subpalette.
Display Data	You can use graphical tools such as charts, gauges, and graphs to display your data. Some display tools are located on the **Controls»Numeric Indicators** subpalette and **Controls» All Controls»Graph** subpalette.
Continue Sampling	For continuous sampling, use a While Loop. If you are using hardware timing, you also need to set the `DAQmx Timing.vi` sample mode to Continuous Samples. To do this right-click the terminal of the `DAQmx Timing.vi` labeled **sample mode** and click **Create»Constant**. Click the box that appears and select **Continuous Samples**.
Stop Measurement	`DAQmx Stop Task.vi` (This VI is optional, clearing the task automatically stops the task.)
Clear Task	`DAQmx Clear Task.vi`

Using a DAQmx Channel Property Node in LabVIEW

You can use property nodes in LabVIEW to manually configure the channels. To create a LabVIEW property node, complete the following steps:

1. Launch LabVIEW.
2. Create the property node in a new VI or in an existing VI.
3. Open the block diagram view.
4. From the **Functions** toolbox, select **All Functions»NI Measurements»DAQmx - Data Acquisition**, and select `DAQmx Channel Property Node`.
5. Left-click inside the box labelled **Property**, and select **Active Channels**. This allows you to specify exactly what channel(s) you want to configure. If you want to configure several channels with different properties, separate the lists of properties with another **Active Channels** box and assign the appropriate channel to each list of properties.

Note If you do not use Active Channels, the properties are set on all of the channels in the task.

6. Right-click **ActiveChans**, and select **Add Element**. Left-click the new **ActiveChans** box. Navigate through the menus, and select the property you wish to define.
7. Change the property to read or write to either get the property or write a new value. Right-click the property, go to **Change To**, and select **Write**, **Read**, or **Default Value**.
8. After you have added the property to the property node, right-click the terminal to change the attributes of the property, add a control, constant, or indicator.
9. To add another property to the property node, right-click an existing property and left-click **Add Element**. To change the new property, left-click it and select the property you wish to define.

Note Refer to *LabVIEW Help* for information about property nodes and specific NI-DAQmx properties.

Specifying Channel Strings in NI-DAQmx

Use the channel input of **DAQmx Create Channel** to specify the SCXI-1521/B channels. The input control/constant has a drop-down menu showing all available external channels. You can right-click the physical channel input, select **I/O Name Filtering**, and check **Internal Channels**. This allows you to select the SCXI-1521/B excitation channels. The strings take one of the following forms:

- Single device identifier/channel number—for example `SC1Mod1/ch0`
- Multiple, noncontinuous channels—for example `SC1Mod1/ch0, SC1Mod1/ch4`
- Multiple continuous channels—for example `SC1Mod1/ch0:4` (channels 0 through 4)
- Excitation on a particular SCXI-1521/B channel—for example `SC1Mod1/_Vex0`, `SC1Mod1/_Vex1`

Once you have a task containing SCXI-1521/B channels, you can set the properties of the channels programmatically using the **DAQmx Channel Property Node**.

Text Based ADEs

You can use text based ADEs such as LabWindows/CVI, Measurement Studio, Visual Basic, .NET, and C# to create code for using the SCXI-1521/B.

LabWindows/CVI

LabWindows/CVI works with the **DAQ Assistant** in MAX to generate code for a strain task. You can then use the appropriate function call to modify the task. To create a configurable channel or task in LabWindows/CVI, complete the following steps:

1. Launch LabWindows/CVI.
2. Open a new or existing project.
3. From the menu bar, select **Tools»Create/Edit DAQmx Tasks**.
4. Choose **Create New Task In MAX** or **Create New Task In Project** to load the DAQ Assistant.
5. Configure the NI-DAQmx strain task following the instructions in the *Creating a Strain Global Channel or Task* section.
6. The DAQ Assistant creates the code for the task based on the parameters you define in MAX and the device defaults. To change a

property of the channel programmatically, use the `DAQmxSetChanAttribute` function.

Note Refer to *NI LabWindows/CVI Help* for more information about creating NI-DAQmx tasks in LabWindows/CVI and NI-DAQmx property information.

Measurement Studio (Visual Basic, .NET, and C#)

When creating a strain task in Visual Basic .NET and C#, follow the general programming flow in Figure 5-1. You can then use the appropriate function calls to modify the task. This example creates a new task and configures an NI-DAQmx strain channel on the SCXI-1521/B. You can use the same functions for Visual Basic .NET and C#.

Create a new task with the channel object. In this example, an analog input channel object is used since reading the voltage from a Wheatstone bridge configuration is an analog input operation. The following text is a function prototype example:

```
void AIChannelCollection.CreateStrainGageChannel(
    System.String physicalChannelName,
    System.String nameToAssignChannel,
    System.Double minVal,
    System.Double maxVal,
    AIStrainGageConfiguration
    strainGageConfiguration,
    AIExcitationSource excitationSource,
    System.Double excitationValue,
    System.Double gageFactor,
    System.Double initialBridgeVoltage,
    System.Double normalGageResist,
    System.Double poissonRatio,
    System.Double leadWireResist,
    AIStrainUnits units);
```

To actually create and configure the channel, modify the following example code or the code from one of the shipping examples as needed to suit your application:

```
Task myTask = new
NationalInstruments.DAQmx.Task("myTaskName");
MyTask.CreateStrainGageChannel (
    "SC1Mod1/ai0", // System.String
    physicalChannelName
    "strain0", // System.String nameToAssignChannel
    -0.001, // System.Double minVal
```

```
    0.001, // System.Double maxVal
    AIStrainGageConfiguration.QuarterBridgeI, //
    AIStrainGageConfiguration
    strainGageConfiguration
    AIExcitationSource.Internal, //
    AIExcitationSource excitationSource
    3.3, // System.Double excitationValue
    2.0, // System.Double gageFactor
    0.0, // System.Double initialBridgeVoltage
    120.0, // System.Double normalGageResist
    0.3, // System.Double poissonRatio
    0.0, // System.Double leadWireResist
    AIStrainUnits.Strain); // AIStrainUnits units
// setting attributes after the channel is created
AIChannel myChannel = myTask.AIChannels["strain0"];
```

Notes You can create and configure the strain task in MAX and load it into your application with the function call `NationalInstruments.DAQmx.DaqSystem.Local.LoadTask`

Refer to *NI Measurement Studio Help* for more information about creating NI-DAQmx tasks in LabWindows/CVI and NI-DAQmx property information.

Other Application Documentation and Material

Refer to the ADE manual and the DAQ analog input examples that come with your application software for more detailed information about programming the SCXI modules for scanning in multiplexed mode.

Calibrating the Strain System

There are two types of calibration important to verifying the accuracy of a strain measurement system. Device calibration ensures the accuracy of the SCXI-1521/B. System calibration involves removing potential error-causing variables such as offset and verifying the accuracy of the strain element through shunt calibration.

Calibrating the SCXI-1521/B

The SCXI-1521/B is shipped with a calibration certificate and is calibrated at the factory to the specifications described in Appendix A, *Specifications*. Calibration constants are stored inside the calibration EEPROM and provide software correction values your application development software uses to correct the measurements for errors in the module.

External Calibration

Most external calibration documents for SCXI modules are available to download from `ni.com/calibration` by clicking **Manual Calibration Procedures**. For external calibration of modules not listed there, Basic Calibration Service or Detailed Calibration Service is recommended. You can get information about both of these calibration services from `ni.com/calibration`. NI recommends performing an external calibration once a year.

Calibrating the System

You should perform offset null compensation or shunt calibration on transducers in the system to improve accuracy. This is considered system, or end-to-end, calibration.

Offset Null Compensation

Performing an offset null compensation removes offset in the measurement system. Factors such as imperfections in the strain gauge, electrical offset in the measurement system, signal leads with significant lead resistance, as well as other system variables can create offset. Refer to the *Offset Null Compensation* section of Chapter 4, *Theory of Operation*, for information about how to perform offset null compensation.

Shunt Calibration

Performing shunt calibration removes gain or amplitude errors in the measurement system. Factors such as non-ideal gauge resistance and temperature fluctuations, as well as other system variables can create these errors. Refer to the *Shunt Calibration* section of Chapter 4, *Theory of Operation*, for information about how to perform shunt calibration.

A

Specifications

This appendix lists the specifications for the SCXI-1521/B modules. These specifications are typical at 25 °C unless otherwise noted.

Analog Input

Number of channels 24

Voltage gain 42

Input coupling ..... DC

Overvoltage protection..... ±11 V powered on and off

Inputs protected..... <AI 0..24>

Transfer

Nonlinearity ..... 0.02% max

Gain error

After calibration[1]..... 0.1% reading max

Before calibration[2] ..... 4.0% of reading max

Input offset error ..... 7 mV max
1 mV typ

[1] This is the error after software correction. Gain error is taken into account in the software correction coefficients stored in the onboard EEPROM. These constants are applied automatically when using NI-DAQmx.

[2] This is the error before software calibration.

Dynamic

Minimum scan interval (per channel)

- ±0.012% accuracy .....3 µs
- ±0.006% accuracy .....10 µs
- ±0.0015% accuracy .....20 µs

Noise RTI[1]

- 0.1 to 10 Hz .....2.5 μV_{pp}
- >10 Hz .....1 μV_{rms} in 1 MHz bandwidth

Filter

Lowpass filter type .....2-pole Butterworth (12 dB/octave rolloff)

3 dB bandwidth.....10 Hz

Stability

Recommended warm-up time.....30 minutes

Gain drift.....±11 ppm/°C max
±4 ppm/°C typ

Offset drift .....±3 µV/°C max
±1 µV/°C typ

Offset Null Compensation

Range .....±0.45% of excitation voltage

Resolution.....4,096 counts of resolution (±9,600 µε offset null compensation range, 4.4 µε resolution for GF = 2.0)

[1] Includes excitation voltage noise contribution.

Excitation

Type	Constant voltage
Settings	0.0 to 5.0 V in 1,023 steps
Error	±20 mV ±0.3% max
Maximum output current	21 mA
Load regulation (open to 240 Ω)	0.08%
Temperature drift	±0.0025%/°C ±30 µV/°C max
Protection	Surge arrestors in parallel with excitation terminals, shunt to ground, short circuit protected

Bridge Completion

SCXI-1521	350 Ω, 0.1%, 2 ppm/°C max, 55 mW at 50 °C
SCXI-1521 long-term stability	0.02%/yr
SCXI-1521B	120 Ω, 0.1%, 2 ppm/°C max, 55 mW at 50 °C
SCXI-1521 B long-term stability	0.02%/yr

Shunt Calibration

Type	Shunt across quarter-bridge completion resistor
Shunt resistor	Fixed 100 kΩ, 0.1%, 10 ppm/°C, 150 mW
Switch resistance	15 Ω max 7.5 Ω typ

Power Requirements (from SCXI Backplane)

V+ .....18.5 to 25 VDC, +170 mA min

V– .....–18.5 to –25 VDC, –170 mA min

+5 V .....+4.75 to 5.25 VDC, 50 mA min

Physical

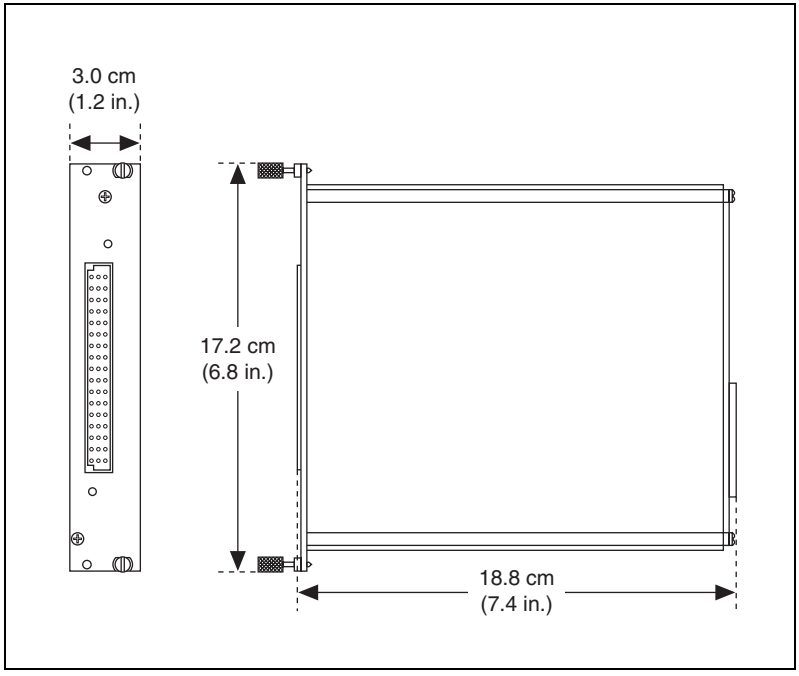


Figure A-1. SCXI-1521/B Dimensions

Weight .....748 gm (26.4 oz)

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel-to-earth..... Input should remain within ±11 V of ground. Measurement Category I

Channel-to-channel ..... Input should remain within ±11 V of ground. Measurement Category I

Caution Do *not* use for measurements within Measurement Categories II, III, or IV.

Environmental

Operating temperature..... 0 to 50 °C

Storage temperature ..... –20 to 70 °C

Humidity ..... 10 to 90% RH, noncondensing

Maximum altitude ..... 2,000 m

Pollution Degree (indoor use only)..... 2

Safety

The SCXI-1521/B is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1
- CAN/CSA-C22.2 No 61010-1

Note For UL and other safety certifications, refer to the product label, or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

Emissions.....EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz

Immunity .....EN 61326:1997 + A2:2001, Table 1

EMC/EMI .....CE, C-Tick, and FCC Part 15 (Class A) Compliant

Note For EMC compliance, operate this device with shielded cabling.

CE Compliance

The SCXI-1521/B meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

Low-Voltage Directive (safety).....73/23/EEC

Electromagnetic Compatibility Directive (EMC).....89/336/EEC

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

B

Removing the SCXI-1521/B

This appendix explains how to remove the SCXI-1521/B from MAX and an SCXI or PXI/SCXI combination chassis.

Removing the SCXI-1521/B from MAX

To remove a module from MAX, complete the following steps after launching MAX:

1. Display the list of installed devices and interfaces by clicking the **+** next to the **Devices and Interfaces** icon.
2. Click the **+** next to **NI-DAQmx Devices** to display the chassis.
3. Click the **+** next to the appropriate chassis to display the installed modules.
4. Right-click the module or chassis you want to delete and click **Delete**.
5. You are presented with a confirmation window. Click **Yes** to continue deleting the module or chassis or **No** to cancel this action.

Note Deleting the SCXI chassis deletes all modules in the chassis. All configuration information for these modules is also lost.

The SCXI chassis and/or SCXI module(s) should now be removed from the list of installed devices in MAX.

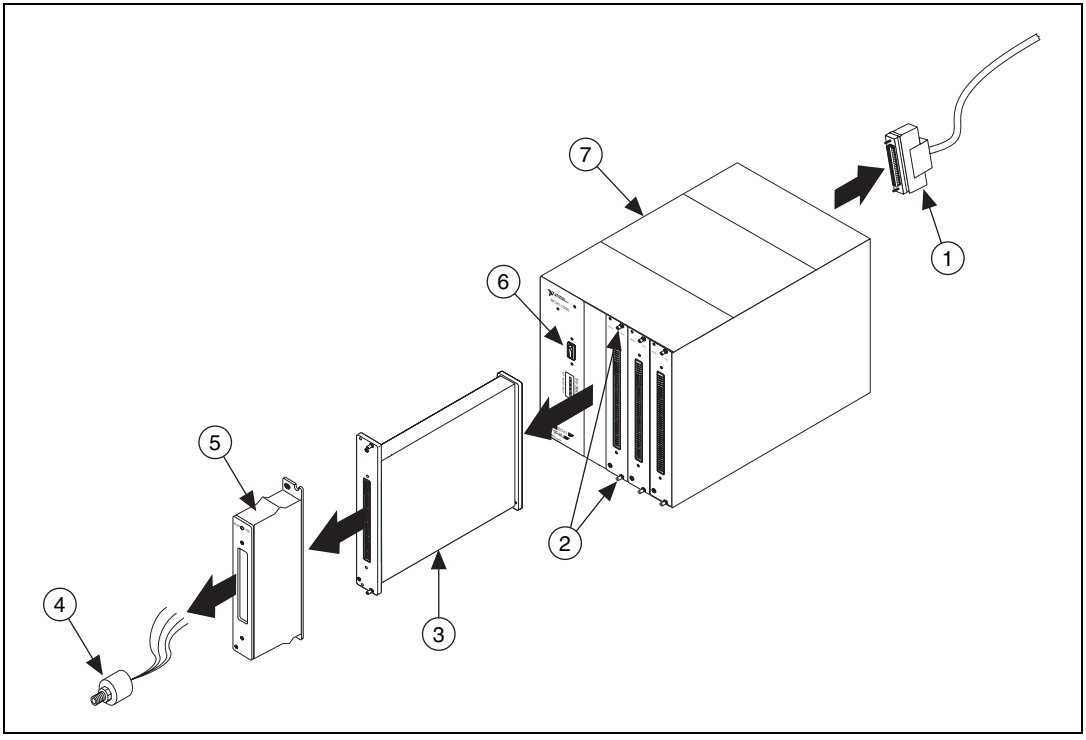
Removing the SCXI-1521/B from a Chassis

Consult the documentation for the chassis and accessories for additional instructions and precautions. To remove the SCXI-1521/B module from a chassis, complete the following steps while referring to Figure B-1:

Note Figure B-1 shows an SCXI chassis, but the same steps are applicable to a PXI/SCXI combination chassis.

1. Power off the chassis. Do *not* remove the SCXI-1521/B module from a chassis that is powered on.
2. If the SCXI-1521/B is the module cabled to the E/M Series DAQ device, disconnect the cable.

3. Remove any terminal block that connects to the SCXI-1521/B.
4. Rotate the thumbscrews that secure the SCXI-1521/B to the chassis counterclockwise until they are loose, but do not completely remove the thumbscrews.
5. Remove the SCXI-1521/B by pulling steadily on both thumbscrews until the module slides completely out.



1 Cable	5 Terminal Block
2 SCXI Module Thumbscrews	6 SCXI Chassis Power Switch
3 SCXI-1521/B	7 SCXI Chassis
4 Strain-Gauge	

Figure B-1. Removing the SCXI-1521/B

C

Common Questions

This appendix lists common questions related to the use of the SCXI-1521/B.

Which version of NI-DAQ works with the SCXI-1521/B, and how do I get the most current version of NI-DAQ?

You must have NI-DAQmx 7.3 or later. Go to `ni.com` and click **Download Software**. Next click **Drivers and Updates**. In the search field enter `NI-DAQ` to find the latest version of NI-DAQ for your operating system.

I have gone over the *Verifying and Self-Testing the Installation* section of Chapter 1, *About the SCXI-1521/B*, yet I still cannot correctly test and verify that my SCXI-1521/B is working. What should I do now?

Unfortunately, there is always the chance that one or more components in the system are not operating correctly that requires you to call or email a technical support representative who can often suggest additional troubleshooting measures. If requesting technical support by phone, have the system nearby so you can try these measures immediately. NI contact information is listed in the *Signal Conditioning Technical Support Information* document.

In NI-DAQmx, can I use channels of different measurement types in the same task?

Yes. You can create channels of various measurement types programmatically in your application using *create channel*. With NI-DAQmx 7.3 or later, you can create a task in MAX that has multiple measurement types.

Will MAX allow me to configure two SCXI-1521/B modules that are in the same chassis in the multiplexed mode with two different E/M Series DAQ devices?

No.

If the SCXI-1521/B module is not cabled directly to a E/M Series DAQ device, can I measure conditioned signals for channels 0 through 7 at the rear connector, for example—using a scope, DMM, or custom acquisition system?

NI does not support or recommend this usage.

Can I use the unused analog input channels of the E/M Series DAQ device if I am directly cabled to the SCXI-1521/B—for example, with the SCXI-1180 feedthrough?

No. E/M Series DAQ device channels 1 through 7 connect to the conditioned analog outputs of SCXI-1521/B channels 1 through 7.

Can I configure the SCXI-1521/B for use in parallel mode?

No. The SCXI-1521/B does not support parallel mode.

Which digital lines are unavailable on the E/M Series DAQ device if I am cabled to an SCXI-1521/B module?

Table C-1 shows the digital lines that are used by the SCXI-1521/B for communication and scanning. These lines are unavailable for general-purpose digital I/O if the SCXI-1521/B is connected to the E/M Series DAQ device.

Table C-1. Digital Signals on the SCXI-1521/B

E/M Series DAQ Device Signal Name	NI-DAQmx SCXI Signal Name	50-Pin Connector	68-Pin Connector	Direction[1]
DIO 0	P0.0	25	52	Output
DIO 4	P0.4	26	19	Input
DIO 1	P0.1	27	17	Output
DIO 2	P0.2	29	49	Output
SCAN CLK	AI HOLD COMP, AI HOLD	36	46	Output

Table C-1. Digital Signals on the SCXI-1521/B (Continued)

E/M Series DAQ Device Signal Name	NI-DAQmx SCXI Signal Name	50-Pin Connector	68-Pin Connector	Direction[1]
PFI 7/ START SCAN	PFI 7/ AI SAMP CLK, AI SAMP	46	38	Input
EXTROBE*	EXTROBE*	37	45	Input

[1] With respect to the E/M Series DAQ device.

In LabVIEW, can I use different input limits for the same SCXI-1521/B physical channel?

Yes. Since the SCXI-1521/B has only one gain, the same value is programmed each time.

Some SCXI modules permit flexible scanning. Does the SCXI-1521/B module permit flexible scanning?

Yes. Flexible scanning is described in Chapter 4, *Theory of Operation*.

Are there any cabling restrictions when using an SCXI-1521/B module with a plug-in E/M Series DAQ device?

Yes. If a chassis contains an SCXI-1521/B, SCXI-1520, SCXI-1530/1531, or SCXI-1140 module, at least one of these modules must be the cabled module. A cabled module is the module connected directly to the E/M Series DAQ device.

Can I use the SCXI-1521/B with a version of NI-DAQ that works under the Macintosh Operating System (Mac OS)?

No, as of NI-DAQ 6.6.1. Check the release notes of later versions of NI-DAQ at `ni.com` for updates.

Is a register-level programming manual available for the SCXI-1521/B?

NI does not support register-level programming for the SCXI-1521/B.

What is the power-on state of the SCXI-1521/B multiplexer, analog bus switches, and configuration settings?

The multiplexer, analog bus switches, and configuration settings are not in a known state immediately after power on. All hardware settings are programmed automatically when beginning an acquisition in LabVIEW or a test panel in MAX.

Which accessories can I use to connect signals to the front of the SCXI-1521/B module?

Refer to Chapter 1, *About the SCXI-1521/B*, for more information.

How do I control the excitation voltage, filter setting, potentiometer settings, and shunt calibration switches from LabVIEW?

Refer to Chapter 3, *Configuring and Testing*, for more information.

What should I take into consideration when I take measurements from sensors with external excitation?

Set the Excitation Source Property to external and Excitation Value Property to the closest value that matches the external excitation level.

Does the SCXI-1317 terminal block contain a CJC temperature sensor?

No.

Are there any user-serviceable parts inside the SCXI-1521/B?

No. There are no fuses, multiturn potentiometers, DIP switches, slide switches, socketed resistors, or jumpers inside the module. Disassembly of the module for any reason voids its warranty and nullify its calibration.

Glossary

Symbol	Prefix	Value
μ	micro	10^{-6}
m	milli	10^{-3}
k	kilo	10^{3}
M	mega	10^{6}
G	giga	10^{9}

Numbers/Symbols

%	Percent.
+	Positive of, or plus.
–	Negative of, or minus.
±	Plus or minus.
<	Less than.
/	Per.
°	Degree.
ε	Strain.
ε_s	Simulated strain.
υ	Poisson's ratio.
Ω	Ohms.
+ 5 V (signal)	+5 VDC source signal.

A

A	Amperes.
A/D	Analog-to-digital.
absolute accuracy	The maximum difference between the measured value from a data acquisition device and the true voltage applied to the input, typically specified as ± voltage.
AC	Alternating current.
ADC	Analog-to-Digital Converter—An electronic device, often an integrated circuit, that converts an analog voltage to a digital number.
ADE	Application development environment such as LabVIEW, LabWindows/CVI, Visual Basic, C, and C++.
AI	Analog input.
AI GND	Analog input ground signal.
AI HOLD COMP, AI HOLD	Scan clock signal used to increment to the next channel after each E/M Series DAQ device analog-to-digital conversion.
amplification	A type of signal conditioning that improves accuracy in the resulting digitized signal by increasing signal amplitude relative to noise.

B

bandwidth	The range of frequencies present in a signal, or the range of frequencies to which a measuring device can respond.
bridge completion resistors	Fixed-valued resistors used to complete a wheatstone bridge when fewer than four of the bridge elements are working strain gauges.
Butterworth filter	A lowpass filter whose characteristics are optimized for maximum flatness in the passband.

C

C	Celsius.
CE	European emissions control standard.

channel	Pin or wire lead to which you apply, or from which you read, an analog or digital signal. Analog signals can be single-ended or differential. For digital signals, channels are grouped to form ports.
chassis	The enclosure that houses, powers, and controls SCXI modules.
CLK	Clock input signal.
CMRR	Common-Mode Rejection Ratio—A measure of the ability of a differential amplifier to reject interference from a common-mode signal, usually expressed in decibels (dB).
CMV	*See* common-mode voltage.
common-mode voltage	Voltage that appears on both inputs of a differential amplifier.
compressive strain	Strain that results from an object being compressed; has a negative value.
current excitation	A source that supplies the current needed by a sensor for its proper operation.
cutoff frequency	The frequency that defines the upper end of the passband of a lowpass filter.

D

D/A	Digital-to-analog.
D*/A	Data/Address.
D GND	Digital ground signal.
DAC	D/A Converter—an electronic device, often an integrated circuit, that converts a digital number into a corresponding analog voltage or current.
DAQ	Data AcQuisition—(1) Collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and processing the measurement data using a computer. (2) Collecting and measuring the same kinds of electrical signals with A/D and/or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer.
DAQ device	A data acquisition device.

DAQD*/A	The data acquisition board data/address line signal used to indicate whether the SER DAT IN pulse train transmitted to the SCXI chassis contains data or address information.
dB	Decibel—The unit for expressing a logarithmic measure of the ratio of two signal levels: $dB = 20\log_{10} V1/V2$, for signals in volts.
DC	Direct current.
device	A plug-in data acquisition board, module, card, or pad that can contain multiple channels and conversion devices.
differential amplifier	An amplifier with two input terminals, neither of which are connected to a ground reference, whose voltage difference is amplified.
DIN	Deutsche Industrie Norme (German Industrial Standard).
DIO	Digital input/output.
drivers/driver software	Software that controls a specific hardware device, such as an E/M Series DAQ device.

E

EEPROM	Electrically Erasable Programmable Read-Only Memory—ROM that can be erased with an electrical signal and reprogrammed. Some SCXI modules contain an EEPROM to store measurement-correction coefficients.
EMC	Electromagnetic compliance.
EMI	Electromagnetic interference.
excitation	Supplying a voltage or current source to energize an active sensor or circuit.

F

FIFO	First-in first-out memory buffer.
filtering	A type of signal conditioning that allows you to remove unwanted frequency components from the signal you are trying to measure.
flexible scanning	The hardware capability to sequence through channels in a scan list in any order.

G

gain	The factor by which a signal is amplified, sometimes expressed in decibels.
gain accuracy	A measure of deviation of the gain of an amplifier from the ideal gain.
gain error	*See* gain accuracy.
Gauge Factor	For a given strain gauge, is the fractional resistance change relative to the strain that caused the resistance change. Thus, Gauge Factor is a measure of strain-gauge sensitivity.
GF	*See* Gauge Factor.

H

half bridge	A Wheatstone bridge consisting of two active strain gauges and two passive fixed-valued resistors.
Hz	Hertz—Cycles per second of a periodic signal.

I

I/O	Input/Output—The transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces.
ID	Identifier.
in.	Inch or inches.
input impedance	The measured resistance and capacitance between the input terminals of a circuit.
instrumentation amplifier	A very accurate differential amplifier with a high input impedance.

L

line resistance	The small, but nonzero, resistance of a lead wire that varies with the lead length and ambient temperature; can cause measurement error if the lead wire carries excitation current.
lowpass filter	A filter that passes signals below a cutoff frequency while blocking signals above that frequency.

M

m	Meters.
M	(1) Mega, the standard metric prefix for 1 million or 10^6, when used with units of measure such as volts and hertz. (2) mega, the prefix for 1,048,576, or 2^{20}, when used with B to quantify data or computer memory.
max	Maximum.
maximum working voltage	The highest voltage with respect to ground that can be applied to an input terminal without damaging the device. Includes both the signal and common-mode voltages.
microstrain	The unit of strain measurement usually denoted by με; one με represents a deformation of 10^{-6}, or 0.0001%.
min	(1) Minutes. (2) Minimum.
MISO	Master-in-slave-out signal.
MOSI	Master-out-slave-in signal.
multiplex	To route one of many input signals to a single output.
multiplexed mode	An SCXI operating mode in which analog input channels are multiplexed into one module output so that the cabled E/M Series DAQ device has access to the module's multiplexed output as well as the outputs of all other multiplexed modules in the chassis.

N

NI-DAQ	The driver software needed in order to use NI E/M Series DAQ devices and SCXI components.
noise	An undesirable electrical signal—Noise comes from external sources such as AC power lines, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to measure.
nonlinearity	For an amplifier, a measure of the maximum output deviation from an ideal linear response in units of percent relative to full scale. The ideal linear response is taken to be a straight line on a plot of measured output voltage to measured input voltage with the ends of the line connecting the extremes of the plot at the full-scale limits.

O

offset error	The output of a system with a zero-volt input.
offset null compensation	The provision in strain-gauge signal conditioning hardware to remove the unwanted offset voltage present at the output of a strain-gauge bridge when no strain is applied.
overvoltage protection	Maximum voltage that does not cause hardware damage.

P

passband	The range of input frequencies that are passed to the filter output without attenuation.
Poisson's ratio	The negative ratio of transverse strain to longitudinal (axial) strain.
pole	A term used to describe the quality of a lowpass filter. In general, the more poles a lowpass filter has, the better it attenuates frequencies beyond the cutoff frequency.
port	A digital port consisting of multiple I/O lines on a E/M Series DAQ device.
pp	Peak to peak.

ppm	Parts per million.
PXI	PCI eXtensions for Instrumentation—An open specification that builds on the CompactPCI specification by adding instrumentation-specific features.

Q

QTR	Terminal for connection to a quarter-bridge completion resistor.
quarter bridge	A Wheatstone bridge consisting of one active strain gauge and three passive fixed-valued resistors.
quarter-bridge completion resistor	The bridge completion resistor in series with the active strain gauge in a quarter-bridge configuration; the quarter-bridge completion resistor must have the same nominal resistance value as the strain gauge.

R

R_g	Gauge resistance.
R_L	Line resistance.
RMA	Return Material Authorization.
rms	Root Mean Square—The square root of the average value of the square of the instantaneous signal amplitude; a measure of signal amplitude.
rolloff	The ratio that a system attenuates signals in the stopband with respect to the passband, usually defined in decibels per octave.
RSVD	Reserved bit, pin, or signal.
RTI	Referred To Input—Calculates a specification relative to the input range.

S

s	Seconds.
S	Samples.
S/s	Samples Per Second—Used to express the rate at which an E/M Series DAQ device samples an analog signal.

sample	An instantaneous measurement of a signal, normally using an analog-to-digital converter in an E/M Series DAQ device.
sample rate	The number of samples a system takes over a given time period, usually expressed in samples per second.
scan	One or more analog samples taken at the same time, or nearly the same time. Typically, the number of input samples in a scan is equal to the number of channels in the input group. For example, one scan acquires one new sample from every analog input channel in the group.
scan rate	The number of scans a system takes during a given time period, usually expressed in scans per second.
SCXI	Signal Conditioning eXtensions for Instrumentation.
SCXIbus	Located in the rear of an SCXI chassis, the SCXIbus is the backplane that connects modules in the same chassis to each other.
sensor	A device that converts a physical phenomenon into an electrical signal.
SER CLK	Serial clock signal used to synchronize digital data transfers over the SER DAT IN and SER DAT OUT lines.
SER DAT IN	Serial data input signal.
SER DAT OUT	Serial data output signal.
shunt calibration	The method of calibrating the gain of a strain-gauge data acquisition channel by placing a resistor of known value in parallel with a bridge element.
signal conditioning	The manipulation of signals to prepare them for digitizing.
simulated strain	A strain measurement where the change in bridge output voltage is not caused by deformation of the specimen being measured; rather, it is caused by temporarily connecting a known resistance in parallel with one of the bridge elements while all the strain gauges in the bridge remain unstrained.
Slot 0	Refers to the power supply and control circuitry in the SCXI chassis.
SLOT 0 SEL	Slot 0 select signal.
SPI CLK	Serial peripheral interface clock signal.

STC strain gauge	Self-Temperature Compensating strain gauge—Has a resistive temperature coefficient that counteracts the thermal expansion coefficient of the material to which the gauge is bonded; thus, makes the system insensitive to changes in temperature.
strain	The fractional deformation of a body under an applied force; is usually given in the units of microstrain, where one microstrain represents a deformation of 10^{-6}, or 0.0001%.
system noise	A measure of the amount of noise seen by an analog circuit or an ADC when the analog inputs are grounded.

T

tensile strain	Strain that results from an object being stretched; has a positive value.
typ	Typical.

U

UL	Underwriters Laboratory.

V

V	Volts.
VDC	Volts, direct current.
VI	Virtual Instrument—(1) A combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument. (2) A LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program
virtual channels	Channel names that can be defined outside the application and used without having to perform scaling operations.
voltage excitation	A source that supplies the voltage needed by a sensor for its proper operation.
V_r	$\left(\frac{V_{CH}}{V_{EX}}\right)_{\text{STRAINED}} - \left(\frac{V_{CH}}{V_{EX}}\right)_{\text{UNSTRAINED}}$

W

W	Watts.
Wheatstone bridge	A circuit arrangement consisting of four resistive elements in a diamond pattern; with excitation voltage applied across two opposing terminals, small resistance changes in the elements are easily detected by measuring voltage changes across the remaining two terminals.

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